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(21) Patentansökningsnummer / Patent application number — *0203728-1*

(86) Ingivningsdatum / Date of filing — *2002-12-16*

Stockholm, 2003-06-30

För Patent- och registreringsverket
For the Patent- and Registration Office

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Avgift
Fee 170:-

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An implantable heart stimulating device, a system including such a device and use of the system

BACKGROUND OF THE INVENTION

1. Field of the invention

The present invention relates to an implantable heart stimulating device with which it is possible to stimulate both the ventricles of a heart, i.e. a bi-ventricular pacer.

The invention also relates to a system including such a device and to the use of the system.

2. Description of the prior art

Several different implantable devices for stimulating a heart are known. The devices are normally able to sense the electrical activity of the heart. Some implantable devices are able to deliver stimulation pulses to both the left and right ventricles of the heart, and sometimes also to the left and right atria.

Devices that are able to deliver stimulation pulses to both the left and right ventricles are also called bi-ventricular pacers. Such devices can be used to treat patients who suffer from different severe cardiac problems, e.g. patients suffering from congestive heart failure (CHF). CHF is defined generally as the inability of the heart to deliver a sufficient amount of blood to the body. CHF can have different causes. It can for example be caused by a left bundle branch block (LBBB) or a right bundle branch block (RBBB). By for example using bi-ventricular pacing, the contraction of the ventricles can be controlled in order to improve the ability of the heart to pump blood. The stimulation pulses to the two ventricles can be delivered

simultaneously but it is also known that the stimulation pulses to the two ventricles are delivered with a short time delay between them in order to optimise the pumping performance of the heart.

US-A-5 720 768 describes different possible electrode positions in order to stimulate or sense the different chambers of the heart.

US-A-6 070 100 describes that electrodes may be positioned in both the left and the right atrium as well as in the left and the right ventricles.

In connection with implantable pacers, in particular pacers which only has the possibility to stimulate the right ventricle, and sometimes also the right atrium, it is known to detect the capture of the heart, i.e. to detect whether the heart actually reacts to a delivered stimulation pulse. If the heart is not captured it is possible to arrange the pacer to deliver a back-up pulse with a higher pulse energy than the first pulse. It is also possible to increase the pulse energy in future stimulation pulses if capture is not detected. In order to save battery it is important that the stimulation pulses are not delivered with an unnecessarily high energy. By varying the energy of the stimulation pulses and by detecting the capture it is possible to find a threshold value for the stimulation pulse energy. Based on the threshold value, a suitable stimulation pulse energy can be determined.

The detection of capture involves several problems. Different signals from the heart or generated by the pacemaker may interfere with each other, which may make the detection of capture difficult. The evoked response that it is intended to detect may thus be hidden because of other electrical phenomena. It is particularly difficult to detect capture in a bi-ventricular pacer, since in such a pacer there are more delivered and detected signals which may interfere with each other.

US-A-6,148,234 describes a system for detecting capture in connection with bi-ventricular or bi-atrial pacing. The document de-

scribes the fact that if a chamber is captured, then there is a biological refractory period during which this chamber cannot be stimulated again. The system described in this document monitors these refractory periods for the different chambers, for example for the two ventricles. When capture is achieved in both ventricles, no intrinsic depolarisation signals can be sensed during the following refractory period. However, where the output level of one of the pacing pulses is insufficient to capture one ventricle, but capture is achieved in the other ventricle, a delayed depolarisation pattern can be detected in the ventricle that was not captured. This delayed depolarisation is due to an interventricular conduction from the ventricle that is captured to the ventricle that is not captured. The system according to this document thus monitors the refractory interval following each delivery of stimulating pulses to the ventricles. A loss of capture is indicated in case such a delayed depolarisation is sensed during the refractory period.

Also US 2001/0049542 A1 describes a system for detecting capture in connection with bi-ventricular or bi-atrial stimulation. The system includes a morphology detector incorporated in a micro controller to allow for the processing of the sensed intra-cardiac electrogram signals (IEGM). The morphology of the IEGM may depend on whether both the ventricles (or atria) have captured or not. By detecting the shape of the IEGM capture may thus be detected.

SUMMARY OF THE INVENTION

The present invention relates in particular to an implantable heart stimulating device including a control circuit comprising:

first pacing means adapted to be connected to a first pacing electrode suited to be positioned in or at a first ventricle of a heart so as to receive signals from said first pacing means such that said first pacing means are able to pace said first ventricle;

first sensing means adapted to be connected to a first sensing electrode suited to be positioned in or at said first ventricle of the

heart so as to transfer signals to said first sensing means such that said first sensing means are able to sense said first ventricle;

second pacing means adapted to be connected to a second pacing electrode suited to be positioned in or at a second ventricle of the heart so as to receive signals from said second pacing means such that said second pacing means are able to pace said second ventricle;

second sensing means adapted to be connected to a second sensing electrode suited to be positioned in or at said second ventricle of the heart so as to transfer signals to said second sensing means such that said second sensing means are able to sense said second ventricle;

said control circuit being arranged to be able to detect an evoked response to a pacing pulse delivered by said first pacing means by sensing, with said first sensing means, within a first time interval that follows after a pacing pulse delivered by said first pacing means;

said control circuit being arranged to be able to detect an evoked response to a pacing pulse delivered by said second pacing means by sensing, with said second sensing means, within a second time interval that follows after a pacing pulse delivered by said second pacing means;

said control circuit being arranged to be able to operate with time cycles corresponding to normal heart cycles;

said control circuit being arranged to, within one such time cycle, deliver pacing pules with both said first pacing means and said second pacing means with a time gap (V-V) between a pacing pulse delivered by said first pacing means and a pacing pulse delivered by said second pacing means, wherein the control circuit is arranged to operate with a time gap (V-V) which is such that a pacing pulse delivered by said second pacing means at least substantially falls within said first time interval.

In such a device, the detection of an evoked response to a pacing pulse delivered by said first pacing means is difficult, since a pacing pulse is delivered by said second pacing means during the time in-

terval in which an evoked response is to be sensed by said first sensing means.

An object of the invention is therefore to provide an implantable heart stimulating device which overcomes the problem described in the previous paragraph. A further object is to provide such a device which is relatively uncomplicated and which can be implemented by relatively simple means.

The above objects are achieved by an implantable heart monitoring device of the above described kind, in which the control circuit is arranged to perform a temporary modification of the operation of the device such that during at least one time cycle no pacing pulse is delivered by said second pacing means during said first time interval.

Since no pacing pulse is delivered by said second pacing means during the first time interval, no pacing pulse from the second pacing means will interfere with the sensing of an evoked response during said first time interval. Consequently, it is possible to detect whether an evoked response is sensed during said first time interval.

According to one preferred embodiment of the device, the control circuit is arranged such that said temporary modification of the operation is done by not delivering any pacing pulse by said second pacing means during said time cycle.

According to an alternative embodiment, said time gap (V-V) is decreased such that the pacing pulse delivered by said second pacing means comes substantially at the same time as the pacing pulse delivered by said first pacing means. By "substantially at the same time" is here meant that the pacing pulse delivered by the second pacing means at least comes before said first time interval. This embodiment has the advantage that the second ventricle may still be paced although capture in the first ventricle can be confirmed.

According to a further alternative, said time gap (V-V) is instead increased such that the pacing pulse delivered by said second pacing means comes after said first time interval. This alternative may for example be advantageous if during the normal operation of the device the pacing pulse delivered by the second pacing means is located quite late in time within said first time interval. This embodiment means that the pacing pulse delivered by the second pacing means is delayed such that it comes after said first time interval. Therefore, also in this case capture in the first ventricle may be confirmed.

Preferably, said temporary modification of the operation is performed during a plurality of time cycles. These time cycles can either follow immediately after each other or with a gap of one or more time cycles between them. In order to increase the reliability of the capture-detection concerning the first ventricle, the temporary modification is thus preferably carried out a plurality of times.

According to an advantageous embodiment, the control circuit is arranged to, during said plurality of time cycles, vary the energy of the pacing pulses delivered by said first pacing means and to detect, with said first sensing means, possible evoked responses during said first time interval such that a suitable pulse energy for the pacing pulses delivered by said first pacing means is determined. According to this embodiment, a so-called stimulation threshold search is thus carried out for the pacing pulses delivered by the first pacing means.

The control circuit can either be arranged to automatically initiate said temporary modification of the operation of the device at predetermined occasions in time or in response to signals of a kind which could be an indication of no capture by said first ventricle. One possibility thereby is to operate the device with a first time window, and to sense, during said first time window, with said first sensing means, signals typical for an R-wave transferred from said second ventricle (or from some other part of the heart, such as the A-V-node) to said first ventricle, wherein the detection of such a

signal typical of an R-wave constitutes said indication of no capture. As described above, a delayed depolarisation pattern can be an indication of the fact that the ventricle in question has not captured. A detection of a typical R-wave during said first time window is thus an indication of the fact that the first ventricle may not have captured. Therefore, it is advantageous to use such a detection for initiating the above described temporary modification of the operation of the device in order to confirm whether capture is obtained or not.

The mentioned first time window preferably ends at least before 400ms after the delivery of said pacing pulse by said first pacing means and starts between 0ms and 150 ms after the delivery of said pacing pulse by said first pacing means. The mentioned first time window thus falls within the period that corresponds to the normal biological refractory period of the first ventricle.

The mentioned first time interval preferably starts 0-30ms after the delivery of a pacing pulse by said first pacing means and is between 25ms and 100ms long. Analogously, the second time interval preferably starts 0ms-30ms after the delivery of a pacing pulse by said second pacing means and is between 25ms and 100ms long. These time intervals are suitable for detecting a possible evoked response in the respective ventricle.

According to another aspect of the invention, the invention provides an implantable heart stimulating system comprising a device according to any of the above embodiments and a first and a second lead connected to said device, wherein said first pacing electrode is arranged on said first lead and said second pacing electrode is arranged on said second lead. Preferably, said first sensing electrode is the same electrode as said first pacing electrode and said second sensing electrode is the same electrode as said second pacing electrode. With such a system, the advantages described above are achieved.

According to another aspect, the invention concerns a use of such a system. According to this use, the system is implanted in a human

or animal being, wherein said first pacing electrode is positioned in or at a first ventricle of the heart of said human or animal being and wherein said second pacing electrode is positioned in or at the second ventricle of said heart. The system is preferably used on a human or animal being suffering from congestive heart failure. The being in question can suffer from a bundle branch block.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig 1	shows schematically a heart stimulating system with a heart stimulating device connected to leads with sensing and pacing electrodes positioned in a heart.
Fig 2	shows schematically a control circuit which may form part of the device.
Fig 3	shows schematically a somewhat more detailed illustration of part of the control circuit of Fig 2.
Fig 4	shows schematically on a time scale signals related to first and second pacing and sensing means.
Fig 5a,b,c	shows schematically the operation of the device.

DESCRIPTION OF PREFERRED EMBODIMENTS

Fig 1 shows schematically an implantable heart stimulating device 10 according to the invention. The device 10 comprises a housing 22. The housing 22 includes a control circuit 14. The device 10 also comprises a connector portion 13. Via the connector portion 13, the device 10 can be connected to different leads. In Fig 1 the device 10 is connected to a first lead 30 and to a second lead 40. The device 10 together with the first 30 and the second 40 leads constitute an implantable heart stimulating system according to the invention. The first lead 30 includes a pacing and sensing electrode 31, 32. In this shown example this electrode 31, 32 is a bipolar electrode with a tip portion 31 and a ring portion 32. However, it is within of the scope of the invention that instead unipolar electrodes can be used, as is known to a person skilled in the art. The second lead 40 has a corresponding electrode 41, 42.

Fig 1 also schematically illustrates a heart with a right atrium RA, a left atrium LA, a first ventricle 1V (which in this case is the right ventricle RV) and a second ventricle 2V (which in this case is the left ventricle LV). The electrode 31, 32 is positioned in the first ventricle 1V in order to be able to pace and sense this ventricle 1V. The electrode 41, 42 is positioned so as to pace and sense the second ventricle 2V. The second lead 40 may for example be introduced via the right atrium RA and the coronary sinus such that the electrode 41, 42 is positioned in for example the middle or great cardiac vein of the heart. How to introduce the lead 40 in this manner is known to a person skilled in the art. Although not shown in Fig 1, it is also possible that the system is connected to further leads with electrodes positioned in order to sense and/or pace the right atrium RA and the left atrium LA.

Fig 2 shows schematically the control circuit 14 in some more detail. The control circuit 14 includes a memory 15 connected to a control portion 20. The control circuit 14 comprises first pacing means 18. These means 18 are adapted to be connected to a first pacing electrode 31, 32, which, as shown in Fig 1, is positioned so as to receive signals from the first pacing means 18 such that the first pacing means 18 are able to pace the first ventricle 1V. The control circuit 14 also includes first sensing means 16. These means 16 are adapted to be connected to a first sensing electrode 31, 32, which can be positioned in the first ventricle 1V in order to transfer signals to the first sensing means 16. In this manner the first sensing means 16 are able to sense the first ventricle 1V. Although the first pacing electrode could be a different electrode from the first sensing electrode, it is preferred that the same electrode 31, 32 is used both for pacing and sensing.

The control circuit 14 also includes second pacing means 19 adapted to be connected to a second pacing electrode 41, 42 for pacing the second ventricle 2V of the heart. The control circuit 14 also includes second sensing means 17 adapted to be connected to a second sensing electrode 41, 42 in order to be able to sense the

second ventricle 2V of the heart. The second pacing electrode is preferably the same electrode as the second sensing electrode. The control circuit 14 may of course also include means for pacing and sensing the atria of the heart.

Fig 4 shows schematically events related to the first ventricle 1V and the second ventricle 2V on a time scale. The marker 11 represents a pacing pulse delivered by the first pacing means 18 and the marker 12 represents a pacing pulse delivered by the second pacing means 19.

The control circuit 14 is arranged to be able to detect an evoked response to a pacing pulse 11 delivered by the first pacing means 18 by sensing, with the first sensing means 16, within a first time interval ER1. The control circuit 14 is also arranged to be able to detect an evoked response to the pacing pulse 12 delivered by the second pacing means 19 by sensing, with the second sensing means 17, within a second time interval ER2. How to arrange the control circuit 14 in order to detect an evoked response is known to a person skilled in the art. The first time interval ER1 may for example be set to begin 15ms after the delivery of a pacing pulse 11 by the first pacing means 18. The length of the first time interval ER1 may for example be 50ms. Analogously, the second time interval ER2 may start 15ms after the delivery of a pacing pulse 12 by said second pacing means 19 and have a length of about 50ms.

The control circuit 14 is arranged to be able to operate with time cycles corresponding to normal heart cycles. Such an operation is normal for an implantable heart stimulating device. The time cycles are determined by preset timer intervals which also may depend on detected signals. The control circuit 14 is arranged to, within one such time cycle, deliver pacing pulses with both the first pacing means 18 and the second pacing means 19 with a time gap V-V between these pacing pulses.

It can be noted that for a bi-ventricular pacer it is known that it is sometimes advantageous to deliver the pacing pulses with such a

time gap V-V in order to optimise the blood-pumping ability of the heart. In the situation that the present invention relates to, the time gap V-V is such that a pacing pulse 12 is delivered by the second pacing means 19 at a point in time that falls within the mentioned first time interval ER1. It is thereby difficult to detect an evoked response to a pacing pulse 11 delivered by the first pacing means 18. According to the invention, the control circuit 14 is arranged to perform a temporary modification of the operation of the device 10 such that during at least one time cycle, no pacing pulse is delivered by the second pacing means 19 during said first time interval ER1.

The control circuit 14 can be arranged to perform the temporary modification of the operation of the device 10 during a plurality of time cycles - either consecutive time cycles or intermittently. During the temporary modification of the operation, it is possible to detect an evoked response to a pacing pulse 11 delivered by the first pacing means 18, since no pacing pulse is delivered by the second pacing means 19 during the first time interval ER1. By modifying the operation of the device 10 over a plurality of time cycles, it is possible to arrange the control circuit 14 to vary the energy of the pacing pulses 11 delivered by the first pacing means 18 and to detect, with the first sensing means 16, possible evoked responses during the first time interval ER1. By varying the pacing energy, a threshold value of the pulse energy can thereby be determined. How to perform such a threshold search is known to a person skilled in the art.

The control circuit 14 can be arranged to automatically initiate the temporary modification of the device 10 at predetermined occasions in time, for example a predetermined number of times per day or per hour. Alternatively, it is also possible to arrange the control circuit 14 to initiate the temporary modification of the operation upon the detection of signals which may be an indication of loss of capture in the first ventricle 1V.

With reference again to Fig 4, it is difficult to detect an evoked response to the pacing pulse 11, since the pacing pulse 12 occurs

within the first time interval ER1. However, in case the first ventricle 1V is actually captured in response to the pacing pulse 11, then the first ventricle 1V will be in the biological refractory period during for example about 350ms after the ventricle 1V was captured. During this biological refractory period, the first ventricle 1V cannot be depolarised again. However, in case the first ventricle 1V is not captured but the second ventricle 2V is captured (as can be detected during the second time interval ER2), then, in accordance with the above description, the depolarisation of the second ventricle 2V may via the myocardium reach the first ventricle 1V during the period that corresponds to the biological refractory period. It is also possible that such a transferred R-wave TR can originate from some other part of the heart, such as from the A-V-node. Such a transferred R-wave TR can be detected by the first sensing means 16. According to an embodiment of the present invention, the control circuit 14 is therefore arranged to be operated with a first time window RW1 and to sense during this first time window RW1 with said first sensing means 16 signals typically for an R-wave TR transferred from the second ventricle 2V to the first ventricle 1V. The time it takes before such a transferred R-wave TR is sensed by the first sensing means 16 depends on the particular case. The control circuit 14 is arranged to define a suitable such first time window RW1. The first time window RW1 may for example start directly after the delivery of the pacing pulse 11 by the first pacing means 19. The first time window RW1 may for example be 300ms long. It should be noted that in case the first time window RW1 coincides with the point in time when a pacing pulse 12, or a back-up pulse, is delivered by the second pacing means 19, then the sensing of a transferred R-wave TR should preferably be disabled for a short time around such a point or points in time. In other words: the time window RW1 should in this case include short blanking periods during which the sensing of a transferred R-wave is not possible.

It should be noted that the circuit arrangement for detecting an evoked response is preferably different from the arrangement for detecting other signals, such as a transferred R-wave TR. Fig 3 shows schematically a part of the control circuit 14 in some more

detail. Fig 3 illustrates that the first sensing means 16 is connected to an evoked response detection logic 50 and a P- or R-wave detection logic 51. The detection logics 50 and 51 can be seen to form part of the control portion 20 illustrated in Fig 2. Similar detection logics may of course be arranged also for the second sensing means 17. The detection logic 50 is thus optimised to sense an evoked response and the detection logic 51 optimised to detect an R-wave. The detection logic 50 is thus active during the first time interval ER1 and the detection logic 51 is active during the first time window RW1. It is possible that the first time window RW1 partly overlaps with the first time interval ER1 if the detection logics 50, 51 are sufficiently different to distinguish the different signals from each other. However, according to an alternative embodiment the first time window RW1 does not overlap with the first time interval ER1.

With reference again to Fig 4, the control circuit 14 can be arranged such that the detection of a transferred R-wave TR during the first time window RW1 will initiate the above described temporary modification of the operation of the device 10.

Fig 5a, b, c illustrate three different manners of carrying out the temporary modification of the operation of the device 10. Each of the illustrations in Fig 5 shows two time cycles where the operation of the device 10 is normal and a third time cycle where the temporary modification is performed. According to Fig 5a, the control circuit 14 is arranged such that the temporary modification of the operation is done by not delivering any pacing pulse at all by said second pacing means 19 during the time cycle in question. According to Fig 5b, the control circuit 14 is arranged such that the temporary modification is done by decreasing the time gap V-V such that the pacing pulses delivered by the first 18 and second 19 pacing means are at least substantially simultaneous. According to Fig 5c, the control circuit is arranged such that the temporary modification is such that the time gap V-V is increased such that the pacing pulse 12 delivered by the second pacing means 19 comes after the first time interval ER1. In all these cases, it is thus possible to de-

tect an evoked response also in the first ventricle 1V during the first time interval ER1.

The invention also concerns the use of an implantable heart stimulating system as illustrated in Fig 1. The system is thereby implanted in a human or animal being and the first pacing electrode 31, 32 is positioned in or at the first ventricle 1V and the second pacing electrode 41, 42 is positioned in or at the second ventricle 2V as described above. Preferably, the system is used on a human or animal being suffering from congestive heart failure, for example caused by a bundle branch block.

The invention is not limited to the described embodiments but may be varied and modified within the scope of the following claims.

Claims

1. An implantable heart stimulating device (10) including a control circuit (14) comprising:

first pacing means (18) adapted to be connected to a first pacing electrode (31, 32) suited to be positioned in or at a first ventricle (1V) of a heart so as to receive signals from said first pacing means (18) such that said first pacing means (18) are able to pace said first ventricle (1V);

first sensing means (16) adapted to be connected to a first sensing electrode (31, 32) suited to be positioned in or at said first ventricle (1V) of the heart so as to transfer signals to said first sensing means (16) such that said first sensing means (16) are able to sense said first ventricle (1V);

second pacing means (19) adapted to be connected to a second pacing electrode (41, 42) suited to be positioned in or at a second ventricle (2V) of the heart so as to receive signals from said second pacing means (19) such that said second pacing means (19) are able to pace said second ventricle (2V);

second sensing means (17) adapted to be connected to a second sensing electrode (41, 42) suited to be positioned in or at said second ventricle (2V) of the heart so as to transfer signals to said second sensing means (17) such that said second sensing means (17) are able to sense said second ventricle (2V);

said control circuit (14) being arranged to be able to detect an evoked response to a pacing pulse delivered by said first pacing means (18) by sensing, with said first sensing means (16), within a first time interval (ER1) that follows after a pacing pulse delivered by said first pacing means (18);

said control circuit (14) being arranged to be able to detect an evoked response to a pacing pulse delivered by said second pacing means (19) by sensing, with said second sensing means (17), within a second time interval (ER2) that follows after a pacing pulse delivered by said second pacing means (19);

said control circuit (14) being arranged to be able to operate with time cycles corresponding to normal heart cycles;

said control circuit (14) being arranged to, within one such time cycle, deliver pacing pules with both said first pacing means (18) and said second pacing means (19) with a time gap (V-V) between a pacing pulse delivered by said first pacing means (18) and a pacing pulse delivered by said second pacing means (19), wherein the control circuit (14) is arranged to operate with a time gap (V-V) which is such that a pacing pulse delivered by said second pacing means (19) at least substantially falls within said first time interval (ER1) such that the detection of an evoked response to a pacing pulse delivered by said first pacing means (18) is difficult, characterised in that

the control circuit (14) is arranged to perform a temporary modification of the operation of the device (10) such that during at least one time cycle no pacing pulse is delivered by said second pacing means (19) during said first time interval (ER1).

2. An implantable heart stimulating device according to claim 1, wherein the control circuit (14) is arranged such that said temporary modification of the operation is done by not delivering any pacing pulse by said second pacing means (19) during said time cycle.

3. An implantable heart stimulating device according to claim 1, wherein the control circuit (14) is arranged such that said temporary modification of the operation is done by, at least during one time cycle, decreasing said time gap (V-V) such that the pacing pulse delivered by said second pacing means (19) comes substantially at the same time as the pacing pulse delivered by said first pacing means (18).

4. An implantable heart stimulating device according to claim 1, wherein the control circuit (14) is arranged such that said temporary modification of the operation is done by, at least during one time cycle, increasing said time gap (V-V) such that the pacing pulse delivered by said second pacing means (19) comes after said first time interval (ER1).

5. An implantable heart stimulating device according to any of the preceding claims, wherein the control circuit (14) is arranged such that said temporary modification of the operation is performed during a plurality of time cycles.

6. An implantable heart stimulating device according to claim 5, wherein said plurality of time cycles follow immediately after each other.

7. An implantable heart stimulating device according to claim 5, wherein said plurality of time cycles do not follow immediately after each other but with a gap of one or more time cycles between them.

8. An implantable heart stimulating device according to any of the claims 5-7, wherein, during said plurality of time cycles, the control circuit (14) is arranged to vary the energy of the pacing pulses delivered by said first pacing means (18) and to detect, with said first sensing means (16), possible evoked responses during said first time interval (ER1) such that a suitable pulse energy for the pacing pulses delivered by said first pacing means (18) is determined.

9. An implantable heart stimulating device according to any of the preceding claims, wherein the control circuit (14) is arranged to automatically initiate said temporary modification of the operation of the device (10) at predetermined occasions in time.

10. An implantable heart stimulating device according to any of the claims 1-8, wherein the control circuit (14) is arranged to initiate said temporary modification of the operation of the device (10) upon the detection of one signal, or a predetermined number of signals, of a kind which could be an indication of no capture by said first ventricle (1V).

11. An implantable heart stimulating device according to claim 10, wherein the control circuit (14) is arranged to be operated with a

first time window (RW1), and to sense, during said first time window (RW1), with said first sensing means (16) signals typical for an R-wave (TR) transferred from said second ventricle (2V), or from some other part of the heart, to said first ventricle (1V), wherein this first time window (RW1) is not identical with said first time interval (ER1) and does not start before said pacing pulse delivered by said first pacing means (18) and wherein the detection of such a signal typical of an R-wave (TR) constitutes said indication of no capture.

12. An implantable heart stimulating device according to claim 11, wherein the control circuit (14) is arranged such that said first time window (RW1) ends at least before 400ms after the delivery of said pacing pulse by said first pacing means (18).

13. An implantable heart stimulating device according to claim 11 or 12, wherein the control circuit (14) is arranged such that said first time window (RW1) starts between 0 ms and 150 ms after the delivery of said pacing pulse by said second pacing means (18).

14. An implantable heart stimulating device according to any of the preceding claims, wherein the control circuit (14) is arranged such that said first time interval (ER1) starts 0-30ms after the delivery of a pacing pulse by said first pacing means (18) and is between 25ms and 100ms long.

15. An implantable heart stimulating device according to any of the preceding claims, wherein the control circuit (14) is arranged such that said second time interval (ER2) starts 0ms-30ms after the delivery of a pacing pulse by said second pacing means (19) and is between 25ms and 100ms long.

16. An implantable heart stimulating system comprising:

an implantable heart stimulating device (10) according to any of the preceding claims, and

a first (30) and a second (40) lead connected to said device, wherein said first pacing electrode (31, 32) is arranged on said first

lead (30) and said second pacing electrode (41, 42) is arranged on said second lead (40).

17. An implantable heart stimulating system according to claim 16, wherein said first sensing electrode (31, 32) is the same electrode as said first pacing electrode (31, 32) and wherein said second sensing electrode (41, 42) is the same electrode as said second pacing electrode (41, 42).

18. Use of the implantable heart stimulating system according to any of the claims 16 and 17, wherein said system is implanted in a human or animal being and wherein said first pacing electrode (31, 32) is positioned in or at a first ventricle (1V) of the heart of said human or animal being and wherein said second pacing electrode (41, 42) is positioned in or at the second ventricle (2V) of said heart.

19. Use according to claim 18, wherein said human or animal being suffers from congestive heart failure.

20. Use according to claim 18 or 19, wherein said human or animal being suffers from a bundle branch block.

PRV 02-12-16

Abstract

The invention concerns an implantable bi-ventricular heart stimulating device (10) including a control circuit (14) arranged to, within a time cycle, deliver pacing pules with both a first (18) and a second (19) pacing means with a time gap (V-V) between a pacing pulse delivered by these pacing means. The time gap (V-V) can be such that a pacing pulse delivered by the second pacing means (19) at least substantially falls within a first time interval (ER1) in which an evoked response can be expected to a pacing pulse delivered by said first pacing means (18). The control circuit (14) is arranged to perform a temporary modification of the operation of the device such that during at least one time cycle no pacing pulse is delivered by said second pacing means (19) during said first time interval (ER1). The invention also concerns a system including such a device (10) as well as a use of this system.

(Fig 1)

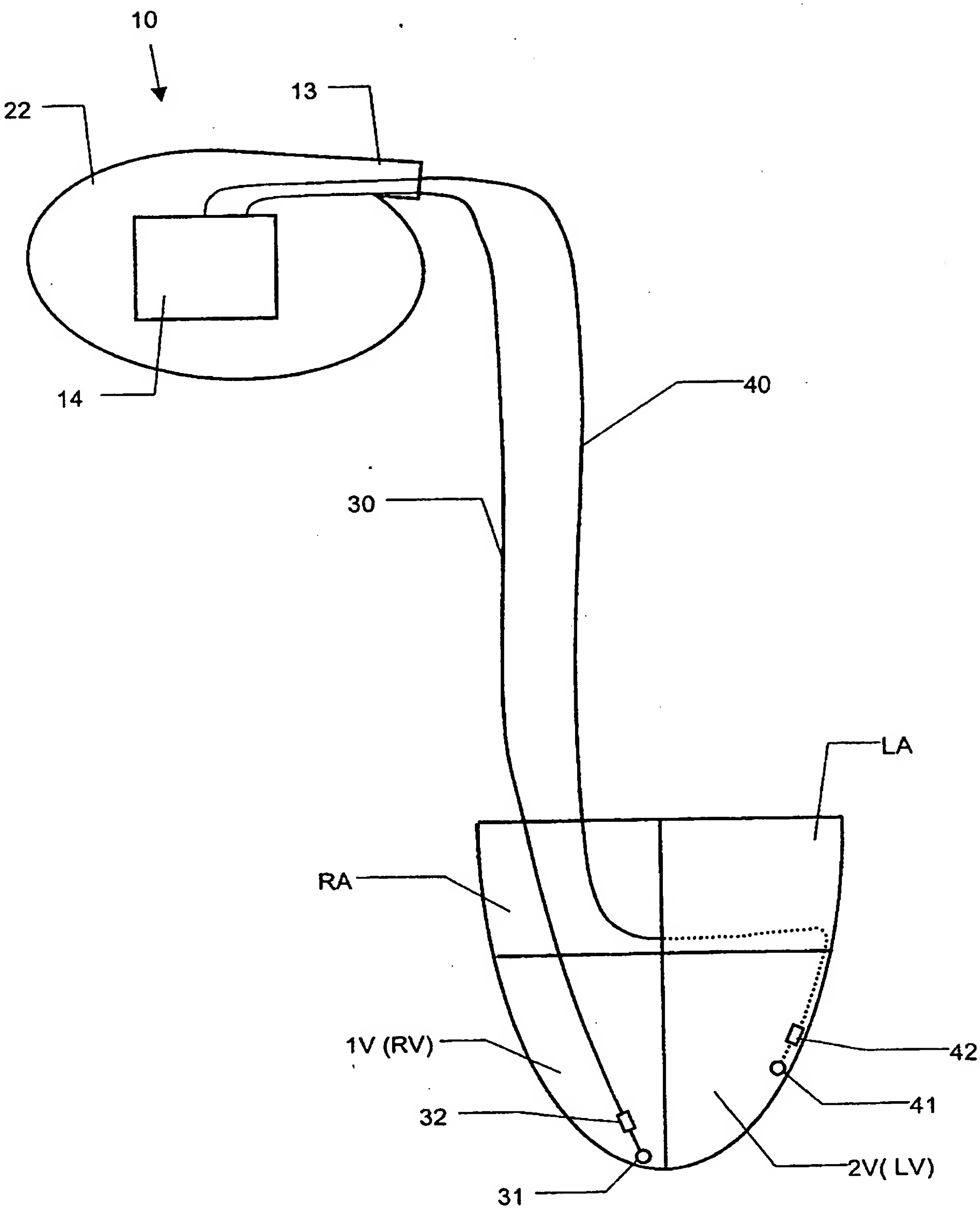

FIG 1

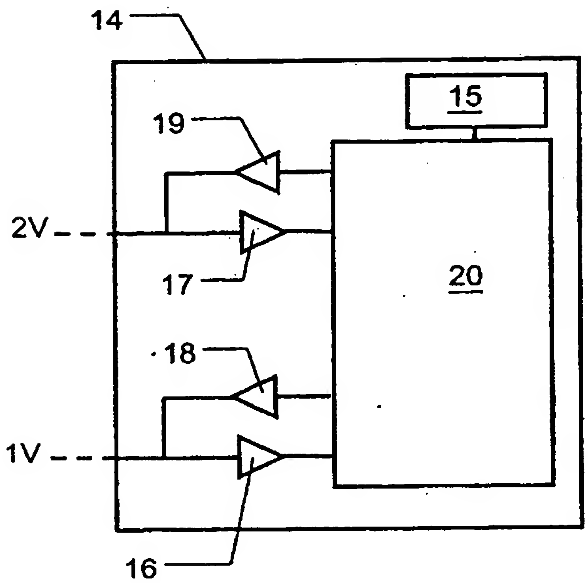

FIG 2

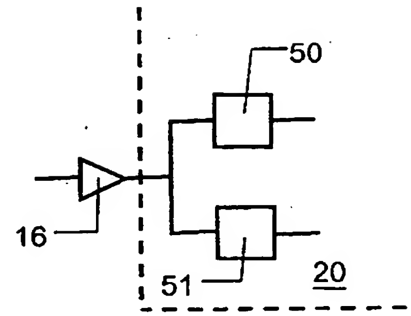

FIG 3

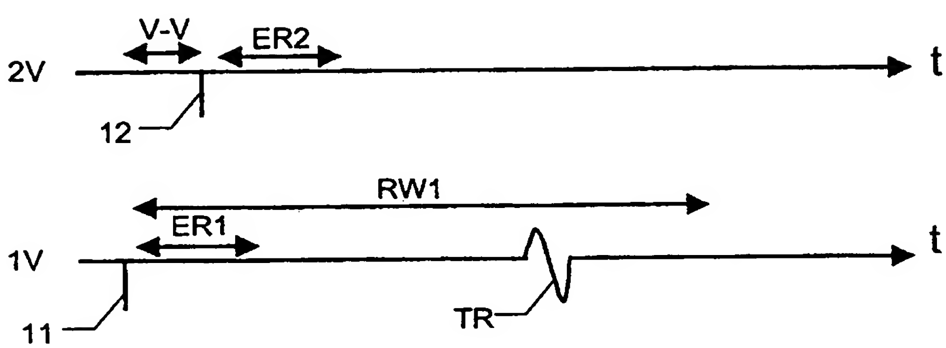

FIG 4

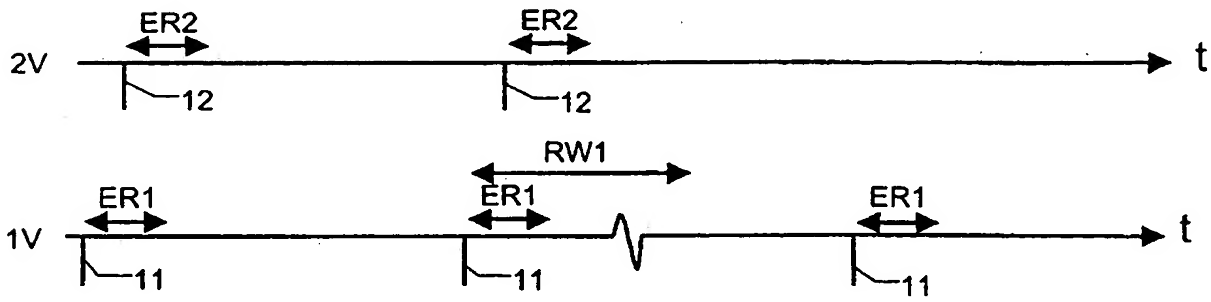

FIG 5a

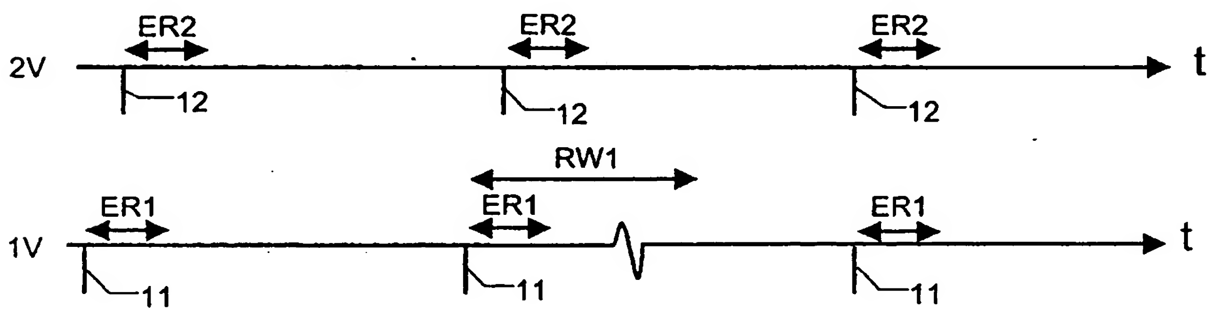

FIG 5b

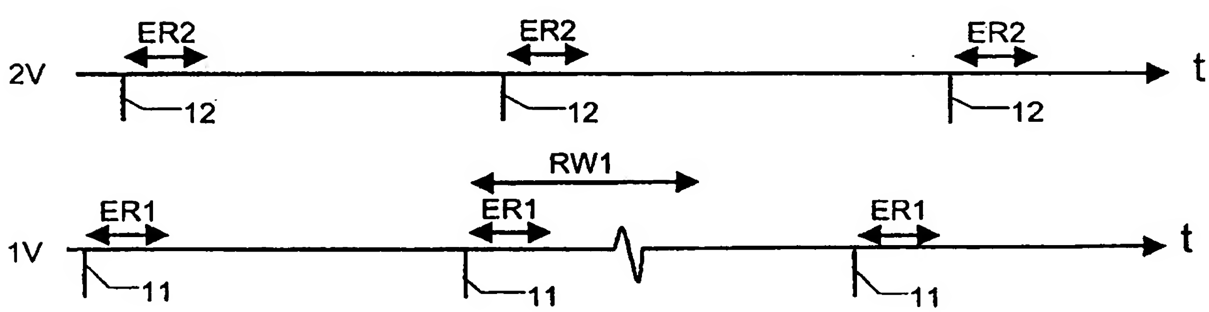

FIG 5c